MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

RECURSIVE BLOCK-BY-BLOCK INTEGRAL EQUATION SOLUTION FOR TRANSIENT DYNAMIC ANALYSIS WITH MEMORY-TYPE ELEMENTS

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An efficient method of computing structural response of multi-story nonlinear base isolated buildings for a given seismic event is presented. Using a recursive block-by-block integral equation formulation (RBBIEF) solution to the governing nonlinear Volterra integral equation, structural base motion coupled to an arbitrary number of nonlinear base isolators can be computed for discrete seismic time histories in an expeditious and exacting manner. The general solution to the governing nonlinear Volterra integral is formulated and subsequently converted into code using MATLAB. The succeeding analysis incorporates modal properties, computed from conventional finite element (FE) techniques, and the generated MATLAB programs to solve a varying set of multi-degree of freedom structures coupled to both linear and nonlinear isolators. Ultimately, an analysis is conducted on a 30-story building that was overly designed using the 1994 Load Resistance Factor Design and the 1994 Uniform Building Codes for earthquake loading. The method demonstrates that the Volterra integration scheme in the time domain is very effective and efficient.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Materials, Processes, and Structures, Modeling and Simulation, Other (Civil Engineering)

KEYWORDS: Finite Element, Nonlinear Dynamic Transient Response, Seismic Response, Volterra integral, Convolution Integral, Nonlinear Structural Base Isolation, Hysteretic isolators

STRUCTURAL HEALTH MONITORING: NUMERICAL DAMAGE PREDICTOR FOR COMPOSITE STRUCTURES

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The use of composite materials in both civil and military applications is increasing as composites potentially offer many advantages over traditional structural materials. Composites typically provide superior strength to weight ratio, better resistance to corrosion, and especially for military applications, greater ballistic protection. Wide use of composites is found in aircraft, armored vehicles, ships and civil structures.

This present research demonstrates the ability to numerically detect damage in a composite sandwich structure using a robust non-linear finite element model (FEM). FEM techniques are used to directly represent damage and the model's response is investigated. Changes in elemental strain and strain frequency, through a Fast Fourier Transform (FFT), is evaluated. Both a cantilevered beam and a simply supported plate are studied.

DoD KEY TECHNOLOGY AREAS: Materials, Processes, and Structures, Manufacturing Science and Technology (MS&T), Modeling and Simulation, Other (Civil Engineering)

KEYWORDS: Structural Health Monitoring**,** Finite Element Method, Composites, DYNA3D, and Non-Destructive Damage Detection

MODELING THE BIODYNAMICAL RESPONSE OF THE HUMAN THORAX WITH BODY ARMOR FROM A BULLET IMPACT

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The objective of this study is to develop a finite element model of the human thorax with a protective body armor system so that the model can adequately determine the thorax's biodynamical response from a projectile impact. The finite element model of the human thorax consists of the thoracic skeleton, heart, lungs, major arteries, major veins, trachea, and bronchi. The finite element model of the human thorax is validated by comparing the model's results to experimental data obtained from cadavers wearing a protective body armor system undergoing a projectile impact. When the model is deemed valid, a parametric study is performed to determine the components of the model that have the greatest effect on its biodynamical response to a projectile impact.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation, Conventional Weapons

KEYWORDS: Finite Element Analysis, Human Thorax Model, Impact Analysis, Body Armor

FLOW CHARACTERISTICS OF LIQUID EPOXY UNDERFILL IN A NARROW GAP FOR FLIP CHIP DEVICES

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The flow characteristics of a liquid epoxy encapsulant designed as an underfill for flip chip computer devices was studied in a controlled manner. Different temperatures, patterns, underfills, and points of application were used to investigate the characteristics of capillary flow through a narrow gap to determine optimal conditions of importance in computer flip chip manufacturing. Observations on flow front uniformity, void formations, distance/time covered, were recorded for all experimental runs. Qualitative visual data was recorded to corroborate the trends found for liquid underfill flow in a flip chip device. This data has been used to generate time-distance plots for determining optimal conditions for flow. The results of this work provide useful fundamental insight into fluid mechanics issues of flip chip computer device manufacturing posed by the challenges of continually decreasing computer chip size.

DoD KEY TECHNOLOGY AREA: Manufacturing Science and Technology (MS&T)

KEYWORDS: Flip Chip, Capillary Flow, Liquid Epoxy Underfill